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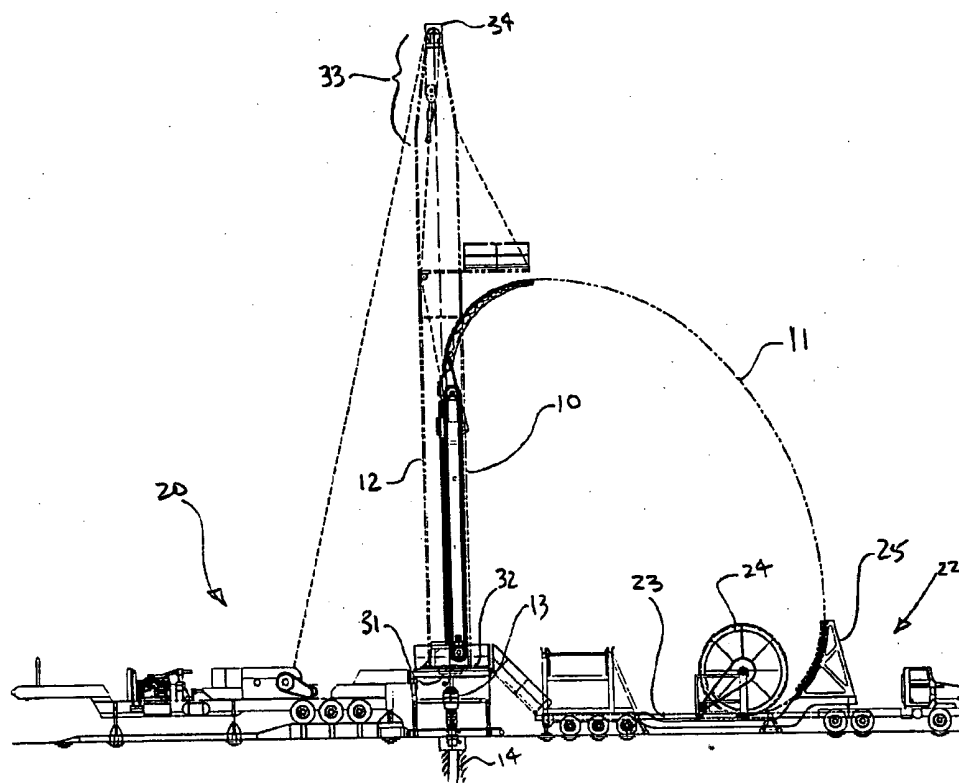
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(54) Titre : INJECTEUR LINEAIRE DE TUYAUX EN SPIRALES

(54) Title: LINEAR COILED TUBING INJECTOR



(57) Abrégé/Abstract:

An injector is provided for injecting and withdrawing large diameter coiled tubing comprising a linear section of gripping blocks driven on an endless chain conveyor. The coiled tubing is forced into frictional engagement with the blocks by a corresponding linear array of rollers. The injector is not restricted in length and thus provides a linear driving section of configurable length for providing superior injection and pulling capacities. In combination with the strong draw works, derrick and rotary table of a conventional rig enable making up both sectional tubing for assembling BHA's, drilling surface hole and making up to non-rotating coiled tubing from the injector.



**"LINEAR COILED TUBING INJECTOR"****FIELD OF THE INVENTION**

The invention relates to apparatus for injecting coiled tubing, and more particularly to an injector having a long, linear tubing gripping section formed of a linearly extending portion of endless conveyor of grooved blocks and substantially continuous opposing rollers.

**BACKGROUND OF THE INVENTION**

The general background relating to coiled tubing injector units is described in U.S. Patent No. 5,839,514 and 4,673,035 to Gipson which are incorporated herein by reference for all purposes.

Coiled tubing has been a useful apparatus in oil field operations due to the speed at which a tool can be run in (injected) and tripped out (withdrawn) from a well bore. Coiled tubing is supplied on a spool. An injector at the wellhead is used to grip and control the tubing for controlled injection and withdrawal at the well. As coil tubing cannot be rotated, drilling with coiled tubing is accomplished with downhole motors driven by fluid pumped downhole from surface.

As stated, coiled tubing has more recently become a contender in the drilling industry, due to the potential to significantly speed drilling and reduce drilling costs through the use of continuous tubing. The most significant cost saving factors include the reduced pipe handling time, reduced pipe joint makeup time, and reduced leakage risks.

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1           In spite of the significant potential cost savings through the use of  
2 coiled tubing, the injector has limited its application to deeper wells.

3           Coiled tubing has been used primarily on shallow wells. One reason  
4 is due to the low tubing string pulling strength of many conventional coiled tubing  
5 injectors as compared to the draw works provided with conventional jointed tubing  
6 derricks. Further, a conventional wellhead injector tends to inject tubing which has  
7 a residual bend therein. As one can imagine, a residual bend results in added  
8 contact and unnecessary forces on the walls of the drilled hole or casing, increasing  
9 frictional drag and causing an offset positioning of the tubing within the hole.  
10 Occasionally the coiled tubing can wad up in the hole (like pushing a resilient rope  
11 through a tube) and cannot be injected any further downhole or ever actually reach  
12 total depth.

13           As described in US Patent 5,842,530 to Smith et al. (Smith),  
14 apparatus is disclosed which is directed to providing a single rig having both  
15 conventional and coiled tubing capability. Smith describes how jointed tubing is  
16 used during the vertical, and substantially linear, drilling and switching to non-  
17 rotation tubing and downhole motors after deviating the well to the horizontal.  
18 However, by combining the two technologies in a single rig, Smith's mast is limited  
19 in its crown and draw works capacity. Further, Smith discloses the use of a  
20 conventional injector.

21           A conventional injector comprises two continuous, parallel and  
22 opposing conveyors having grooved shoes or blocks mounted thereon such as that  
23 disclosed in US Patent 5,533,668 to Council et al. for Halliburton Company.

1 Oklahoma. The opposing conveyors have facing portions where the multiplicity of  
2 gripping blocks run parallel for gripping the tubing therebetween, typically positioned  
3 inline, directly adjacent and above the wellhead.

4 One characteristic of the dual conveyor injectors is that the facing  
5 grooved blocks must have absolutely synchronous timing and engagement with the  
6 coiled tubing, the failure to do so being associated with damage to the coiled tubing.  
7 Damage to the coiled tubing further reduces the lifespan of tubing already suffering  
8 a short lifespan due to reversing stresses inherent in the technique.

9 In US Patent 5,839,514 to Gipson, an improved injector comprises a  
10 grooved reel and hold-down rollers for imparting the gripping force necessary to  
11 drive the coiled tubing. This reel type injector, while causing less damage to the  
12 tubing than the block type is limited in pull capability, in part due to the short tubing  
13 gripping length. The gripping length of reel-type coiled tubing drives is limited by the  
14 circumference of the reel; the maximum circumference being limited to less than  
15 360 degrees due to the inability to permit overlap tubing wrapped around a grooved  
16 driving reel.

17 Deeper wells can be accessed, for either workover or drilling purposes  
18 if the pull strength can be increased. Further, deeper wells usually require larger  
19 diameter tubing to handle greater string weight and to minimize fluid pumping power  
20 requirements. As the fluid for driving mud motors is delivered down the bore of  
21 tubing, fluid friction causes significant pressure drop and thus require large power  
22 sources at the pumps. The larger the tubing, the lower the fluid friction losses and  
23 the lower the power requirements.

1           Rigs utilizing either the dual conveyor or the reel type injectors have  
2   had difficulty in dealing with larger diameter tubing. Further, while the use of coiled  
3   tubing has provided for faster operation to depth and out again, the equipment has  
4   a higher capital and operating cost. For example, coiled tubing rigs use more  
5   complicated and expensive equipment, have higher power requirements for pumps  
6   and the like and the repeatedly deformed coiled tubing has a limited life and must  
7   be periodically replaced with new coiled tubing.

8           Further, coiled tubing apparatus is typically provided on a single  
9   transportable rig which provides a spool of coiled tubing, an injector and its own  
10   mast which is designed for light or small diameter coiled tubing, portability and  
11   generally low pull weight. The mast and rigs generally are not suitable for work with  
12   deeper wells.

13

SUMMARY OF THE INVENTION

1  
2           The linear injector of the present invention extends coiled tubing  
3 capability beyond that known heretofore. In combination with a conventional joint d  
4 drilling rig, none of the functionality of the conventional rig is sacrificed while  
5 achieving enhanced capabilities by the addition of coiled tubing.

6           With the preferred embodiment, coiled tubing is driven along a linear  
7 section of an endless chain conveyor with an opposing linear array of rollers. With  
8 prior art dual conveyors, gripper blocks pull on both sides of coiled tubing and the  
9 present invention only pulls on one side. Thus, while the invention's pulling  
10 capability per lineal length of tubing capability is seemingly halved as compared to  
11 prior art injectors, applicant has found that by eliminating the prior art parallel chain  
12 drives, the difficulty to synchronize the two drives is avoided and the substitution of  
13 non-driving rollers for one side of the tubing injector results in less damage to the  
14 coiled tubing. Further, by eliminating the challenge of maintaining dual chain  
15 synchronicity, the novel injector is able to take unrestricted advantage of an  
16 extended length of a linear driving section, thus providing superior injection and  
17 pulling capability.

18           Accordingly, in one preferred aspect of the invention, deep wells can  
19 be drilled with coiled tubing even from the surface due to the combination of  
20 enabling the use of full diameter tubing, implementing a straightener and using an  
21 injector which is capable of applying both significant injector force on a drilling bit  
22 and full pulling capability for tripping out of the deep wells. An injector of 20 feet in  
23 length is capable of a nominal pulling capacity of about 100,000 lb. force. Further,

1 suspension of the preferred injector in a conventional derrick having strong draw  
2 works and a rotary table permits operation with both conventional sectional tubing,  
3 including BHA, and simplifying the making up to coiled tubing.

4 In a broad aspect of the invention then, coiled tubing injection  
5 apparatus is provided comprising:

- 6 • a chain conveyor extending about an endless path and having at  
7 least one linear section aligned with the wellbore;
- 8 • a multiplicity of gripper blocks conveyed and driven by the chain  
9 conveyor, the gripper blocks forming a substantially continuous  
10 coiled tubing support while traversing the linear portion;
- 11 • a linear array of a multiplicity of rollers in parallel and opposing  
12 arrangement to the linear section of the chain conveyor for forming  
13 a corridor therebetween and through which the coiled tubing  
14 extends, the rollers urging the coiled tubing into frictional  
15 engagement with the gripper blocks;
- 16 • means for supporting the gripper blocks against the normal forces  
17 produced by the linear array of rollers; and
- 18 • means for driving the chain conveyor along the endless path so as  
19 to drive the gripper blocks which frictionally drive the coiled tubing  
20 along the corridor.

21 Preferably a tubing straightener is positioned between the apparatus  
22 and a source of coiled tubing, just preceding the corridor between the linear portion

1 of the gripper blocks and the linear array of rollers. Jacking means are provided for  
2 adjusting the normal force imposed by the rollers against the coiled tubing.

3 In another embodiment, the linear injector can be pivotally mounted to  
4 a mobile transport for aligning the linear injector with wellheads at any angle to the  
5 surface.

6 Further, in another embodiment, apparatus for injecting and  
7 withdrawing coiled tubing into and out of a well comprises combining the above  
8 linear coiled tubing injector suspended it in the derrick of a conventional drilling rig  
9 positioned over the well. Preferably the injector is movable between a first position  
10 aligned with the well for injecting and withdrawing coiled tubing and a second  
11 position out of alignment so that the derrick can trip in and out sectional tubing from  
12 the well. More preferably, a rotary table in the conventional rig is used to make up  
13 connections, in the second position between sectional tubing and in the first position  
14 between sectional tubing and the coiled tubing.

15 The apparatus enables the practice of a novel process for injecting  
16 and withdrawing coiled tubing from a well comprising: providing a conventional  
17 derrick positioned over the well; suspending a coiled tubing injector in the derrick for  
18 driving the coiled tubing, the injector having a bottom end secured adjacent the well,  
19 the injector having a linear coiled tubing drive corridor extending between bottom  
20 end and a top end of the injector, the corridor being aligned with the well; and  
21 straightening the coiled tubing before it enters the injector.

22



## BRIEF DESCRIPTION OF THE DRAWINGS

1  
2               Figure 1a is a side elevation view of one arrangement of the novel  
3 linear injector in combination with a conventional jointed tubing derrick and draw  
4 works. For convenience, the coiled tubing transport rig is illustrated aligned with the  
5 rig for the conventional derrick;

6               Figure 1b is a plan view of the arrangement according to Fig. 1a  
7 illustrating a preferred out of alignment arrangement of the coiled tubing transport  
8 rig and the conventional derrick;

9               Figure 2 is a side elevation view of the linear injector arrangement  
10 according to Fig. 1a, the linear injector being in a shipping position on its coiled  
11 tubing trailer;

12              Figure 3 is a side elevation view of the linear injector arrangement  
13 according to Fig. 1a, the lower end of the linear injector being pinned conventional  
14 derrick and the upper end being in a partially raised position as lifted by the derrick's  
15 draw works;

16              Figure 4 is a partial side view of the linear injector of Fig. 1a installed  
17 in the conventional derrick and aligned over the wellhead;

18              Figure 5 is a partial close up side view of the linear injector of Fig. 4  
19 illustrating the straightener and nip of the blocks and the rollers;

20              Figure 6 is a plan, cross-sectional view of one embodiment of the  
21 head sprocket and drive for illustrating the a hydraulic arrangement for loading the  
22 rollers which force coiled tubing into frictional contact with the blocks;

1           Figure 7 illustrates a cross sectional view of one embodiment of a  
2 manual arrangement for loading the rollers against the coiled tubing using a  
3 Belleville washer feedback system;

4           Figures 8a – 8c illustrate isometric, side and end views respectively of  
5 one embodiment of the gripper block assembly, wherein conventional roller chain is  
6 fitted with gripper blocks;

7           Figure 9 is an isometric view of an alternate embodiment of gripper  
8 block, specifically illustrating a single offset roller gripper block;

9           Figure 10 is an isometric view of a train of offset roller gripper blocks  
10 according to Fig. 9, one of which is shown fitted with an idler;

11           Figure 11 is an isometric view of an alternate embodiment of gripper  
12 block, specifically illustrating the narrow block of a matched pair of roller gripper  
13 blocks;

14           Figure 12 is an isometric view of the wider second block of a matched  
15 pair of roller gripper blocks according to Fig. 11;

16           Figure 13 is an isometric view of the wider second block of Fig. 12  
17 fitted with idlers;

18           Figure 14 is an isometric view of a train of roller gripper blocks  
19 according to Figs. 11 and 12 extending over a sprocket; and

20           Figure 15 illustrates a side elevation view of an alternate  
21 implementation of the novel linear injector, illustrating three stages (a),(b),(c) of an  
22 all-in-one coiled tubing rig utilizing the novel injector for workovers or for directional  
23 drilling of predominately shallow wells.

1                    DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

2                    Having reference to Fig. 1a, a new injector 10 for coiled tubing 11 is  
3                    provided. Use of the new injector 10, in combination with a suitable support or  
4                    derrick 12 can utilize straightened, full diameter tubing at the wellhead 13, now truly  
5                    providing substantially all the advantages of both conventional jointed drill tubing  
6                    and coiled tubing.

7                    More particularly, a conventional jointed tubing drilling rig  
8                    (conventional rig) 20 is positioned at a well 14. A novel coiled tubing transport rig  
9                    22, according to the present invention, is also positioned at the well 14. For  
10                   reasons elucidated in greater detail later, the preferred coiled tubing rig 22  
11                   incorporates only means for transporting the novel injector 10 and does not include  
12                   pumps and the like, and thus is substantially less complicated and less expensive  
13                   than prior art coiled tubing injector rigs.

14                   More particularly, the transport rig 22 comprises a mobile trailer or  
15                   truck frame 23 having a coiled tubing spool 24 mounted thereon. Conventional  
16                   means (not detailed) are provided for managing coiled tubing dispensing and  
17                   retrieving, such as a tubing traversing mechanism and spool drives. A curved guide  
18                   25 is provided for directing the coiled tubing 11 approximately along a parabolic  
19                   loop.

20                   Best shown in Fig. 2, the transport rig 22 forms a transport bed 26 for  
21                   storing and transporting the linear injector 10 to the well 14. Once at the well, rather  
22                   than utilizing the transport rig 22 to support the linear injector 10, it is mounted and  
23                   supported in the conventional rig 12.

1           As illustrated, the conventional rig 20 may comprise a mobile trailer  
2 30, the derrick 12 rising from the rotary table 31 at the drilling floor 32 to the draw  
3 works 33 in the crown 34 and means for mounting the linear injector 10 in the  
4 derrick 12.

5           As shown in plan in Fig. 1b, the transport rig 22 and conventional rig  
6 20 are oriented out of alignment for retaining full functionality of the conventional rig  
7 20. Accordingly, a catwalk 35 and pipe rack 36 are able to access the drilling floor  
8 32. Further, mud pumps 37 and mud tanks 38 accompany the conventional rig 20.

9           More particularly, the linear injector 10 is a continuous conveyor 40  
10 having an upper 41 and a lower end 42. As shown in Figs. 2 and 3, the lower end  
11 42 of the linear injector 11 is rotationally pinned in the derrick 12 above the drilling  
12 floor 32. The linear injector 11 is hoisted into the derrick 12. As shown in Fig. 3, a  
13 cable 29 from the derrick's draw works 33 is directed about an idler 39 located  
14 about the monkeyboard and is attached to the upper end 41 of the linear injector 10.

15           Using the draw works 33 and cable 29, the upper end 41 is hoisted  
16 upwardly, pivoting the linear injector 11 about the bottom end 42 and into position.  
17 The linear injector 11 is aligned in the derrick 12 and in-line with the well 14. The  
18 linear injector 10 is secured for suspending it in the derrick 12.

19           The linear injector 11 can be alternated between two positions within  
20 the derrick. In a first position, the linear injector is inline with the wellhead 13 for  
21 injection and withdrawal of coiled tubing 11. In a second position, the linear injector  
22 10 is shifted or set aside in the derrick 12 to take the injector out of alignment from  
23 the well 14. When out of alignment, the derrick 12 can be used in a conventional

1 manner; more specifically to enable sectional tubing to be pulled up the catwalk 35  
2 and into the derrick 12 and utilizing the rotary table 31 for making up threaded  
3 joints.

4           Having reference to Fig. 4, the linear injector 10 comprises this rigid  
5 and continuous chain conveyor 40, which when secured in the derrick has its lower  
6 end adjacent the drilling floor 32 and a chain 43 extending about an endless and  
7 reversible path 44 therearound. The upper end 41 of the continuous conveyor 40 is  
8 fitted with a gooseneck 46 for guiding the coiled tubing 11.

9           Best shown in Fig. 5, the continuous conveyor 40 is fitted with upper  
10 and lower drive sprockets 47,48. The endless chain 43 is fitted with a multiplicity of  
11 coiled tubing gripper blocks 50; one block 50 per link of the chain 43. The blocks 50  
12 move with the chain conveyor 40. The moving gripper blocks 50 are formed with  
13 grooves 66 to accept the coiled tubing 11.

14           The continuous conveyor 40 provides a long linear section 49. A  
15 linear array of complementary hold-down rollers 51 exert a normal force on the  
16 coiled tubing, urging it into the moving gripper blocks 50 and thereby frictionally  
17 engaging the coiled tubing 11 with minimal damage caused thereto. The long  
18 length of the linear section 49, coupled with the even coiled tubing gripping force  
19 imposes large pulling force on the coiled tubing 11, resulting in significant pulling  
20 capability. The long linear section 49 also accommodates long rigid sectional  
21 strings. As a result, the linear injector 11 can be used in a variety of heretofore  
22 restricted applications including the injection of long strings of downhole tools or in

1 the case of drilling operations, injecting and pulling out large bore coiled tubing 11 in  
2 deep well drilling operations.

3           The length of the linear section 49 is configurable depending upon the  
4 driving force required, but is usually maximized, limited typically by the working  
5 height within the derrick 12. For instance with a working height of about 50 – 60  
6 feet normally provided for making up stands of jointed tubing, the linear section of  
7 the injector 11 may be about 30 feet tall. A straightener 52 and a coiled tubing  
8 guide gooseneck 53 must also be accommodated in the derrick 12.

9           In more detail, and referring to Figs. 5 and 7, the linear array of hold-  
10 down rollers 51 comprises a multiplicity of these rollers, distributed along, parallel to  
11 and facing the linear section 49 of gripper blocks 50. The rollers 51 are similarly  
12 grooved to accept coiled tubing 11. A corridor 60 is formed between the opposing  
13 grooves of the gripper blocks 50 and rollers 51. The coiled tubing 11 extends  
14 through the corridor 60.

15           The moving gripper blocks 50 are movably supported by skate or track  
16 means 61, located along the linear section 49, so as to resist the force produced by  
17 the rollers 51 and thereby grip the coiled tubing 11 therebetween.

18           In one embodiment shown in Figs. 8a-8c, the gripper blocks 50 are  
19 provided as a separate component 63, mounted to brackets 64 on roller chain 43a.  
20 The entire linear section 49 of the continuous conveyor 40 is supported along its  
21 linear section by a linear skate 61a, backing the roller chain 43 of the conveyor 40.

22           In another more preferred embodiment shown in Figs. 9 and 10, the  
23 moving gripper blocks 50 themselves (roller gripper blocks 65) form the continuous

1 chain conveyor 40. Each roller gripper block 65 comprises a block 50 formed with a  
2 semi-circular groove 66, fitted with a replaceable insert 67 which is sized to match  
3 the diameter of the coiled tubing 11 being used. The roller gripper blocks 65 have  
4 an offset link configuration having narrow first bifurcated prongs 68 and second  
5 wider bifurcated prongs 69. Adjacent blocks 65 interconnect with the first prongs 68  
6 fitting between the wider second prongs 69 of the immediately adjacent block 50  
7 with pin 70 pivotally connecting them together.

8 In another embodiment shown in Figs. 11 - 14, again the moving  
9 gripper blocks 50 themselves form the continuous chain conveyor 40 and are fitted  
10 with the grooves 66 and inserts 67. In this embodiment, two types of roller blocks  
11 are provided; one block 75a having closely spaced links 76a and another block 75b  
12 with widely spaced links 76b. Each roller block 75a,75b is mounted to (or formed  
13 with) a pair of parallel links 76a,76b, spaced sufficiently to enable the upper and  
14 lower sprockets 47,48 to pass therebetween (Fig. 14). As shown in Fig. 13, the  
15 roller pin 70, as per the previous embodiment, passes transversely through the links  
16 for pivotally pinning them together.

17 Having reference to Fig. 14, the narrow spaced links 76a fit between  
18 the widely spaced links 76b, the narrow and widely spaced link roller blocks  
19 75a,75b connected in alternating fashion and, when pinned together, form the  
20 continuous chain conveyor 40, shown wrapped about a sprocket 47,48.

21 The interconnecting pins 70 of any block 50 or specific configuration  
22 65,75a,75b are engaged by the upper and lower drive sprockets 47,48. As shown  
23 in Figs 10,13,14 and 5, the transverse or distal end of each pin 70 supports a

1 bearing 80. The bearing 80 forms a hub for a larger diameter roller (not shown)  
2 which engages a backing track 61b, replacing the skate 61a of the earlier  
3 embodiment and enabling the blocks 50 to resist the normal force imposed by the  
4 rollers 51.

5           The chain conveyor 40 is driven at one or both of the upper and lower  
6 sprockets 47,48 preferably using hydraulic motors or planetary drives 85. The  
7 drives 85 are reversible for providing injection force in the CCW direction and pulling  
8 force in the CW (rotation referenced to Fig. 4). The pitch of the conveyor chain 43  
9 is minimized to reduce the diameter of the upper and lower sprockets 47,48,  
10 resulting in a reduced driving moment and reduced drive size.

11           Referring to Fig. 7, in an example of the simplest embodiment, the  
12 rollers 51 are set using adjusting or jacking bolts 90 for exerting a fixed and  
13 consistent force for the size of coiled tubing 11 used. Conical spring or load-  
14 indicating washers 91, such as Belleville washers, are used to set the jacking bolts  
15 90 to the appropriate roller load to maximize normal force without damaging the  
16 coiled tubing 11. Other elastomeric load-indicating washers (not shown) may also  
17 be used.

18           Referring once again to Figs. 4 and 5, a tubing straightener 100 is  
19 located at the upper end 41 of the linear injector 10 so that coiled tubing 11, without  
20 appreciable residual bend, is caused to enter the injector 10, reducing load on the  
21 gripper blocks 50 and rollers 51 and further so that coiled tubing leaves the linear  
22 injector straight. When pulling the coiled tubing 11 back up, the straightener re-



1 bends the tubing to the lowest stress possible unsupported shape – preferably a  
2 parabolic shape.

3 By combining a conventional derrick 12 with coiled tubing capability, a  
4 high capacity draw works 33 and a rotary table 31 is now available. Further, the  
5 physical distance placed between the conventional rig 20 and the source of the  
6 coiled tubing (the spool 24) enables the formation of a large radius parabolic loop  
7 allowing the injector rig to utilize large coiled tubing diameters, including 3.5 inch  
8 typical for use in conventional rigs. The long linear injector 10 is capable of dealing  
9 with large linear lengths 49 of coiled or jointed tubing. The large fluid bore of 3.5  
10 inch tubing reduces fluid friction pumping power requirements from about 1000 HP  
11 to only 5-600 HP at 5,000 feet. It is postulated that a 5,000 foot deep well can be  
12 drilled in about ½ the time due to the elimination of the need to make up joints every  
13 30 feet.

14 The ability to use large bore 3.5", straightened coiled tubing better  
15 mimics, as close as possible, operation with conventional jointed tubing; now  
16 providing: a large pulling capability needed for deep drilling; providing straight tubing  
17 with weight on bit control suitable for controlled drilling immediately; and even for  
18 drilling surface hole. Further, the aforementioned problems associated with residual  
19 bend can be avoided.

20 It has been determined that a 20 foot long linear section 49 provides  
21 pull capability on 3.5 inch tubing of about a maximum of 150,000 pounds, but if oil  
22 contaminated (soaked wet), this capability can drop to about 50,000 pounds. In  
23 practice, the capability would be in excess of 100,000 lbs.

1           Further, it is also known that Bottom Hole Assemblies (BHA)  
2 containing the bit, mud motor and measurement equipment must be made up and  
3 can be in the order of 30 feet in length. Conventional coiled drilling units have tried  
4 various means to make up the BHA, requiring the various pieces to be threaded  
5 together. This is usually a labor intensive job because coiled tubing units are not  
6 normally set up to rotate tubing to make up the joints. Also, occasionally drill collars  
7 are threaded onto the BHA to provide startup drilling weight or improve linear  
8 stability.

9           Further, by combining a conventional derrick 12 with the linear injector  
10 10, the capital costs of the whole operation are reduced. The rig 22 transporting a  
11 linear injector need not have a mast, nor fluid pumping equipment and can simply  
12 include the coiled tubing injector 10 and spool 24. The conventional derrick 12  
13 provides the capability of lifting at the required high pull forces and through the use  
14 of the rotary table 31 enables readily making up BHA and connections onto the non-  
15 rotating coiled tubing 11.

16           Optionally, and referring to Fig. 6, in advanced embodiments, the  
17 force produced by the roller 51 can be dynamically adjusted using hydraulic  
18 actuators 110, further enabling the rollers 51 to adjust the normal gripping force or  
19 optionally to temporarily and sequentially lift the rollers 51 off the coiled or jointed  
20 tubing 11 to pass an upset or other diameter variation. For maintenance and  
21 adjustability, the rollers 51 can be grouped in linear arrays 111 (Fig. 5), each having  
22 several rollers 51 (e.g. five) minimizing the number of actuators 110.

1           In yet another application, as shown in Fig. 15, the linear injector 10,  
2 applied without a conventional derrick, is particularly well suited for shallow  
3 directional drilling or the insertion of downhole tools such as pumps or for  
4 workovers, and is able to provide continuous, straightened tubing into any well,  
5 including a slant wellhead. Without the need for a rotary table or strong draw works,  
6 the linear injector 10 can be located on its own trailer 22 and does not require  
7 further mast superstructure. As shown in Fig. 15, the linear injector 10 can be  
8 transported prone (stage (a)), raised partially for injection through a slat wellhead 13  
9 (stage (b)) or raised completely for injection down a vertical well (stage (c)). A BHA  
10 for directional drilling or a pump can be pre-assembled and carried on an integrated  
11 coiled tubing injector rig for injection without additional equipment.

1 THE EMBODIMENTS OF THE INVENTION FOR WHICH AN  
2 EXCLUSIVE PROPERTY OR PRIVILEGE IS CLAIMS ARE DEFINED AS  
3 FOLLOWS:  
4

5 1. Apparatus for injecting coiled tubing into a wellbore from a source  
6 and withdrawing same comprising:

7 (a) a chain conveyor extending about an endless path and having at  
8 least one linear section aligned with the wellbore;

9 (b) a multiplicity of gripper blocks conveyed and driven by the chain  
10 conveyor, the gripper blocks forming a substantially continuous coiled tubing  
11 support while traversing the linear section;

12 (c) a linear array of a multiplicity of rollers in parallel and opposing  
13 arrangement to the linear section of the chain conveyor for forming a corridor  
14 therebetween and through which the coiled tubing extends, the rollers urging the  
15 coiled tubing into frictional engagement with the gripper blocks;

16 (d) means for supporting the gripper blocks against the normal forces  
17 produced by the linear array of rollers; and

18 (e) means for driving the chain conveyor along the endless path so as  
19 to drive the gripper blocks which frictionally drive the coiled tubing along the corridor  
20 to inject or withdraw coiled tubing.

21

22 2. The apparatus of claim 1 further comprising a tubing straightener  
23 positioned between the apparatus and the coiled tubing source.

24

1           3. The apparatus of claim 2 wherein the straightener is further  
2 positioned just preceding the corridor between the linear portion of the gripper  
3 blocks and the linear array of rollers.

4

5           4. The apparatus of claim 3 further comprising jacking means for  
6 adjusting the normal force imposed by the rollers against the coiled tubing.

7

8           5. The apparatus of claim 4 further comprising:

9           (a) a head sprocket over which the chain conveyor extends; and

10           (b) a tail sprocket over which the chain conveyor extends so that the  
11 linear portion of the chain conveyor is formed along a line substantially tangent  
12 between the head and tail sprockets.

13

14           6. The apparatus of claim 5 wherein the driving means comprises  
15 one or more drives which rotate one or both of the head or tail sprockets.

16

17           7. The apparatus of claim 6 wherein the means for supporting the  
18 linear section of the chain conveyor against normal forces comprises a continuous  
19 track positioned on the opposing side of the chain conveyor from the gripper blocks.

20

1                   8. The apparatus of claim 7 wherein the means for supporting the  
2 linear section of the chain conveyor against normal forces comprises at least one  
3 pair of idlers extending from each gripper block, the idlers engaging and rolling  
4 along the continuous track.

5

6                   9. In combination, apparatus for injecting and withdrawing coiled  
7 tubing into and out of a well comprising:

8                   (a) a conventional drilling rig having a derrick positioned over the well;  
9 and

10                  (b) a coiled tubing injector suspended in the derrick and having a  
11 bottom end secured adjacent the well, the injector forming a linear coiled tubing  
12 drive corridor between bottom end and a top end of the injector, the corridor being  
13 aligned with the well.

14

15                  10. The combination of claim 9 further wherein :

16                  (a) the conventional drilling rig further comprises means for handling  
17 sectional tubing; and

18                  (b) the coiled tubing injector is movable between a first position  
19 aligned with the well for injecting and withdrawing coiled tubing and a second  
20 position out of alignment so that the derrick can trip in and out the sectional tubing  
21 from the well.

22

1                   11. The combination of claim 9 further wherein the conventional drilling  
2 rig further comprises a rotary table so that rotary table is used to make up  
3 connections, in the second position between sectional tubing and in the first position  
4 between sectional tubing and the coiled tubing.

5

6                   12. The combination of claim 11 further comprising a coiled tubing  
7 guide gooseneck at the top end of the injector.

8

9                   13. The combination of claim 12 further comprising a straightener  
10 between the top end of the injector and the gooseneck.

11

12                   14. The combination of claim 13 wherein the height of the injector's  
13 linear corridor is maximized for the height of the derrick.

14

15                   15. The combination of claim 14 wherein the injector is transported to  
16 the well separately from the derrick.

17

18                   16. The combination of claim 15 wherein the derrick has draw works  
19 for lifting the injector into the derrick for suspension therein.

20

- 1                   17. The combination of claim 9 wherein the injector comprises %  
2                   (a) a chain conveyor extending about an endless path and having at  
3                   least one linear section aligned with the well;  
4                   (b) a multiplicity of gripper blocks conveyed and driven by the chain  
5                   conveyor, the gripper blocks forming a substantially continuous coiled tubing  
6                   support while traversing the linear section;  
7                   (c) a linear array of a multiplicity of rollers in parallel and opposing  
8                   arrangement to the linear section of the chain conveyor for forming a corridor  
9                   therebetween and through which the coiled tubing extends, the rollers urging the  
10                  coiled tubing into frictional engagement with the gripper blocks;  
11                  (d) means for supporting the gripper blocks against the normal forces  
12                  produced by the linear array of rollers; and  
13                  (e) means for driving the chain conveyor along the endless path so as  
14                  to drive the gripper blocks which frictionally drive the coiled tubing along the  
15                  corridor.  
16



1                   18.A process for injecting and withdrawing coiled tubing from a well  
2 comprising:

3                   (a) providing a conventional derrick positioned over the well;

4                   (b) suspending a coiled tubing injector in the derrick for driving the  
5 coiled tubing, the injector having a bottom end secured adjacent the well, the  
6 injector having a linear coiled tubing drive corridor extending between bottom end  
7 and a top end of the injector, the corridor being aligned with the well; and

8                   (c) straightening the coiled tubing before it enters the injector.

9  
10                  19.The process as recited in claim 18 wherein the length of the  
11 corridor is maximized in the derrick for maximizing coiled tubing driving capability.

12

13                  20.The process as recited in claim 19 wherein the coiled tubing  
14 driving force is maximized comprising the steps of;

15                  (a) providing, in opposing relation, a multiplicity of gripper blocks and a  
16 multiplicity of rollers for forming the coiled tubing corridor therebetween;

17                  (b) endlessly conveying the gripper blocks along the linear corridor;

18 and

19                  (c) jacking the rollers against the coiled tubing for urging the coiled  
20 tubing into frictional and driving engagement with the gripper blocks,

21

1                   21. The process as recited in claim 19 wherein a downhole motor and  
2 bit are fitted to the coiled tubing for drilling the well.

3

4                   22. The process as recited in claim 21 further comprising:

5                   (a) drilling at least a portion of the well with jointed tubing using the  
6 derrick; and

7                   (b) drilling at least a portion of the well using the coiled tubing.

8

1                   23.Apparatus for injecting coiled tubing into a wellbore from a source  
2 and withdrawing same comprising:

3                   (a) a mobile frame; and

4                   (b) an injector mounted pivotally upon the frame so that the injector  
5 can be aligned with the well and wherein the injector comprises,

6                   i)       a chain conveyor extending about an endless path and  
7 having at least one linear section,

8                   ii)     a multiplicity of gripper blocks conveyed and driven by  
9 the chain conveyor, the gripper blocks forming a substantially  
10 continuous coiled tubing support while traversing the linear section,

11                  iii)    a linear array of a multiplicity of rollers in parallel and  
12 opposing arrangement to the linear section of the chain conveyor for  
13 forming a corridor therebetween and through which the coiled tubing  
14 extends, the rollers urging the coiled tubing into frictional engagement  
15 with the gripper blocks,

16                  iv)    means for supporting the gripper blocks against the  
17 normal forces produced by the linear array of rollers, and

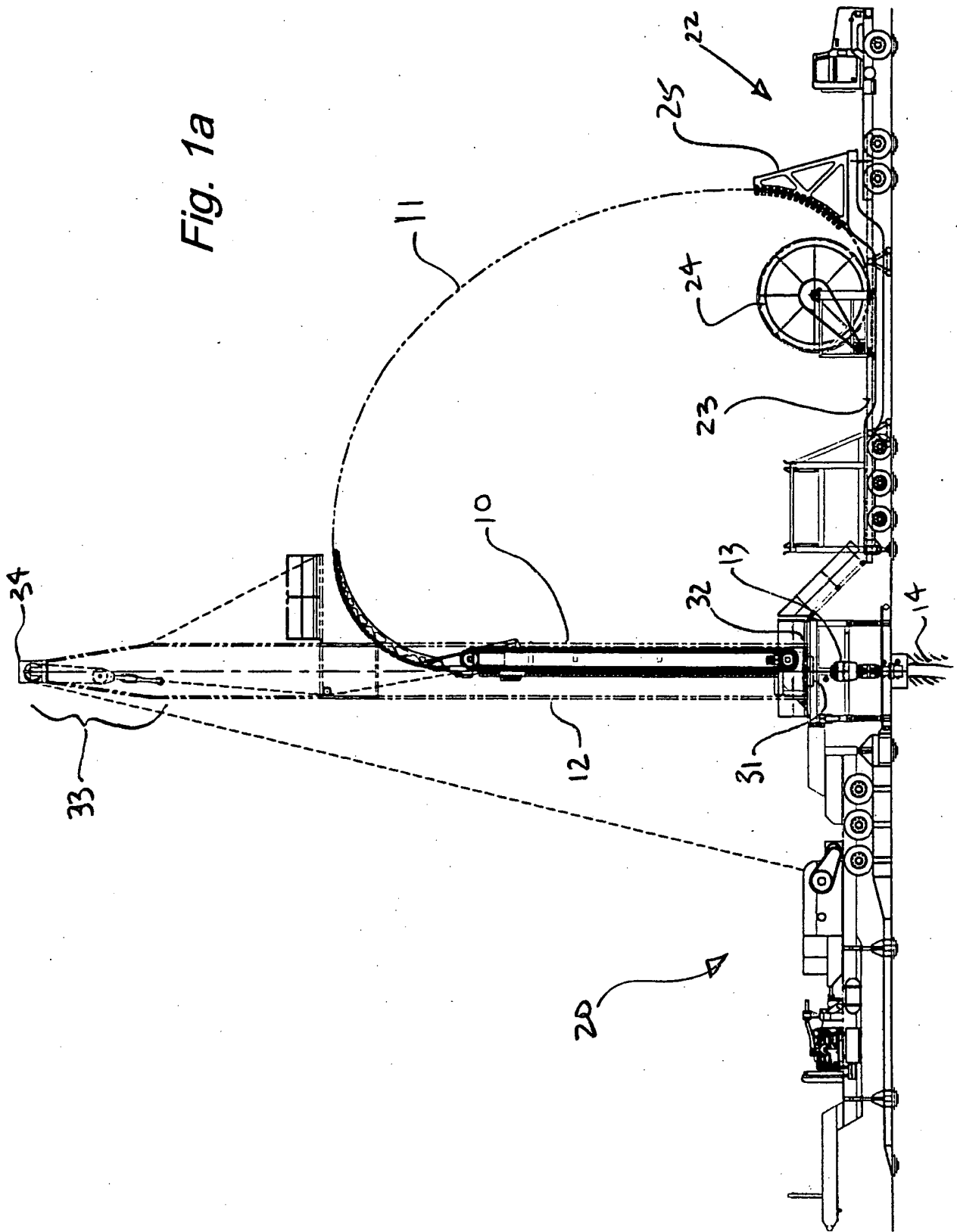
18                  v)    means for driving the chain conveyor along the endless  
19 path so as to drive the gripper blocks which frictionally drive the coiled  
20 tubing along the corridor to inject or withdraw coiled tubing.

21

**"LINEAR COILED TUBING INJECTOR"****ABSTRACT OF THE INVENTION**

An injector is provided for injecting and withdrawing large diameter coiled tubing comprising a linear section of gripping blocks driven on an endless chain conveyor. The coiled tubing is forced into frictional engagement with the blocks by a corresponding linear array of rollers. The injector is not restricted in length and thus provides a linear driving section of configurable length for providing superior injection and pulling capacities. In combination with the strong draw works, derrick and rotary table of a conventional rig enable making up both sectional tubing for assembling BHA's, drilling surface hole and making up to non-rotating coiled tubing from the injector.

Fig. 1a



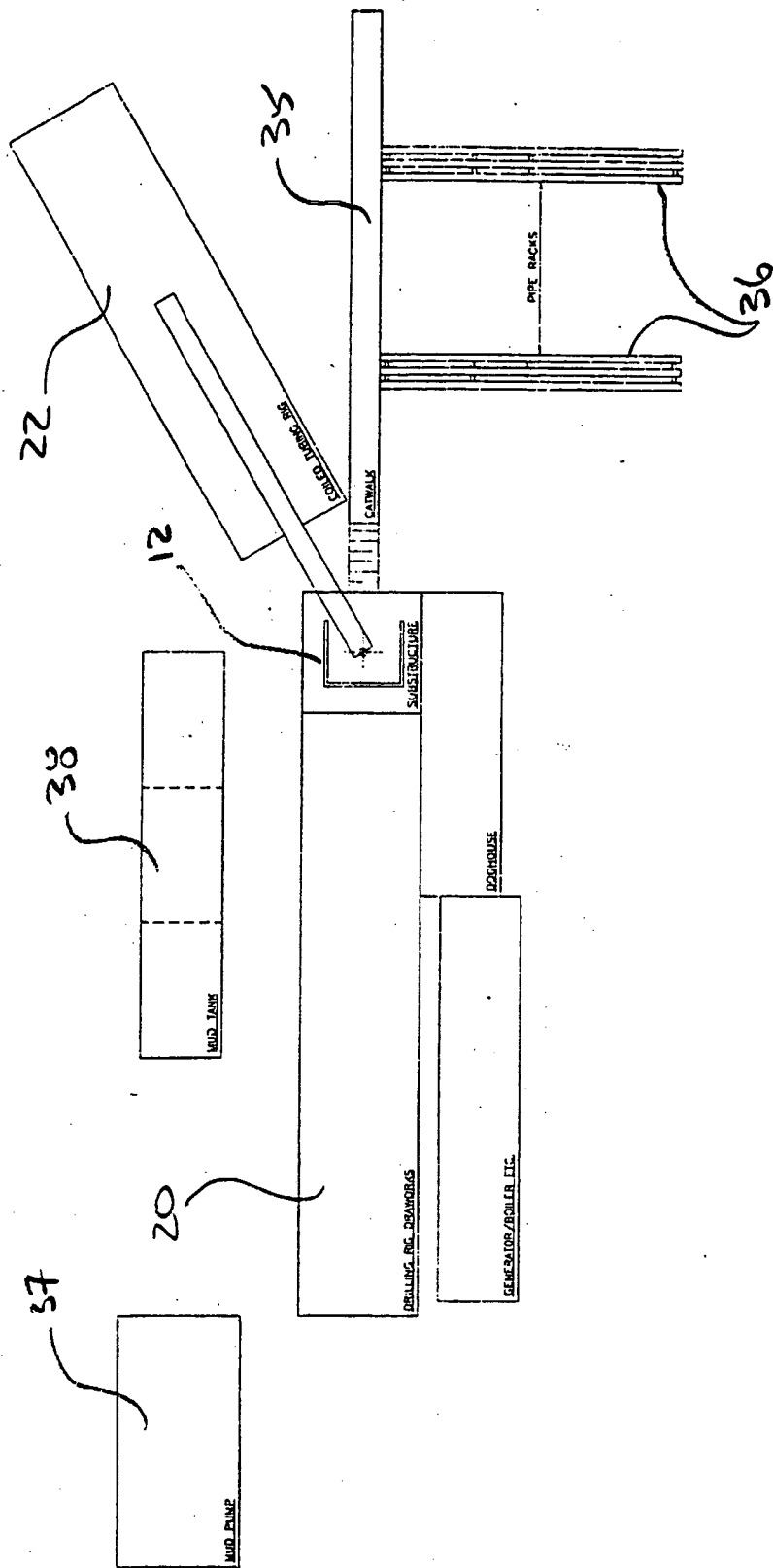


Fig. 1b

Fig. 2

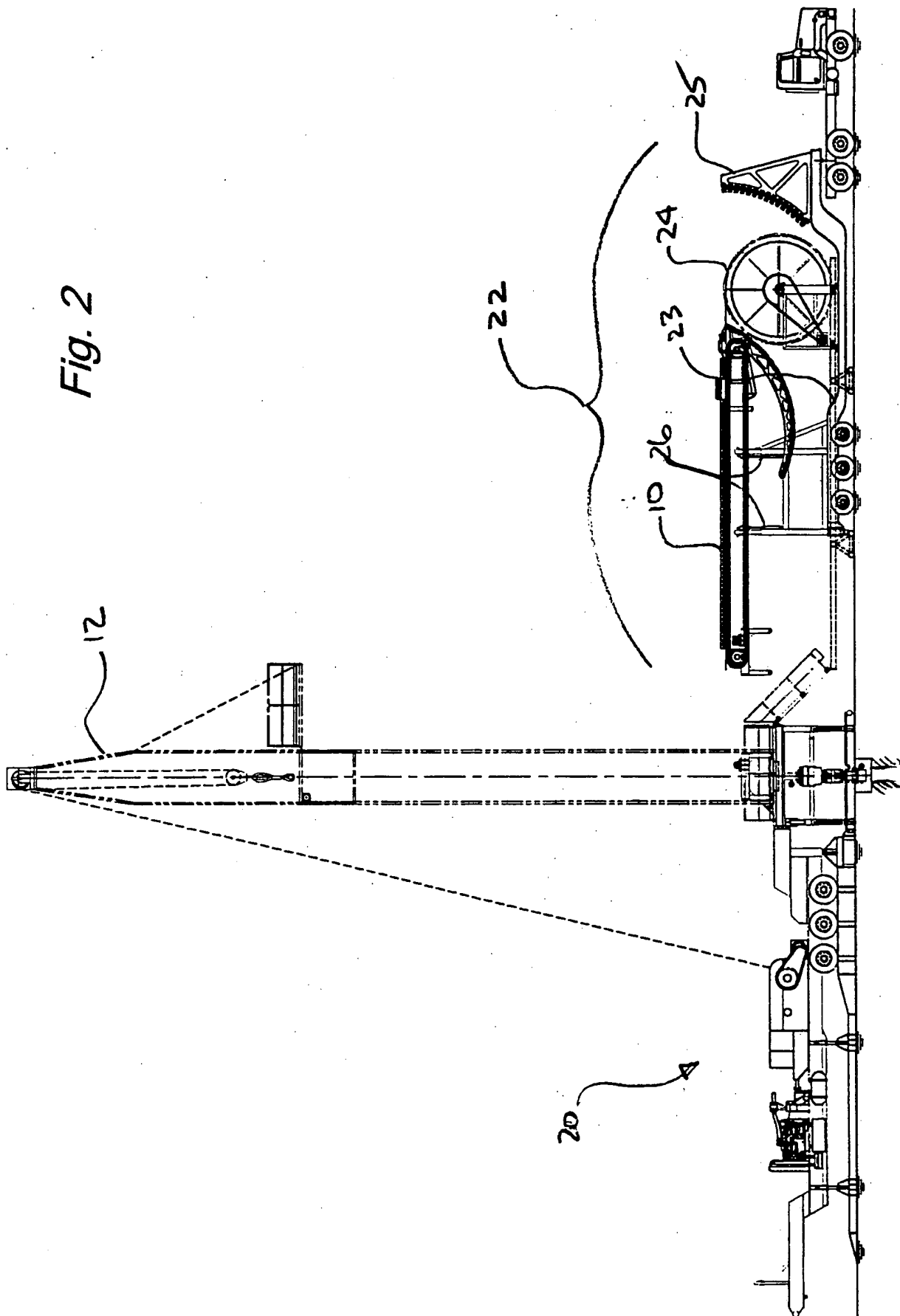


Fig. 3

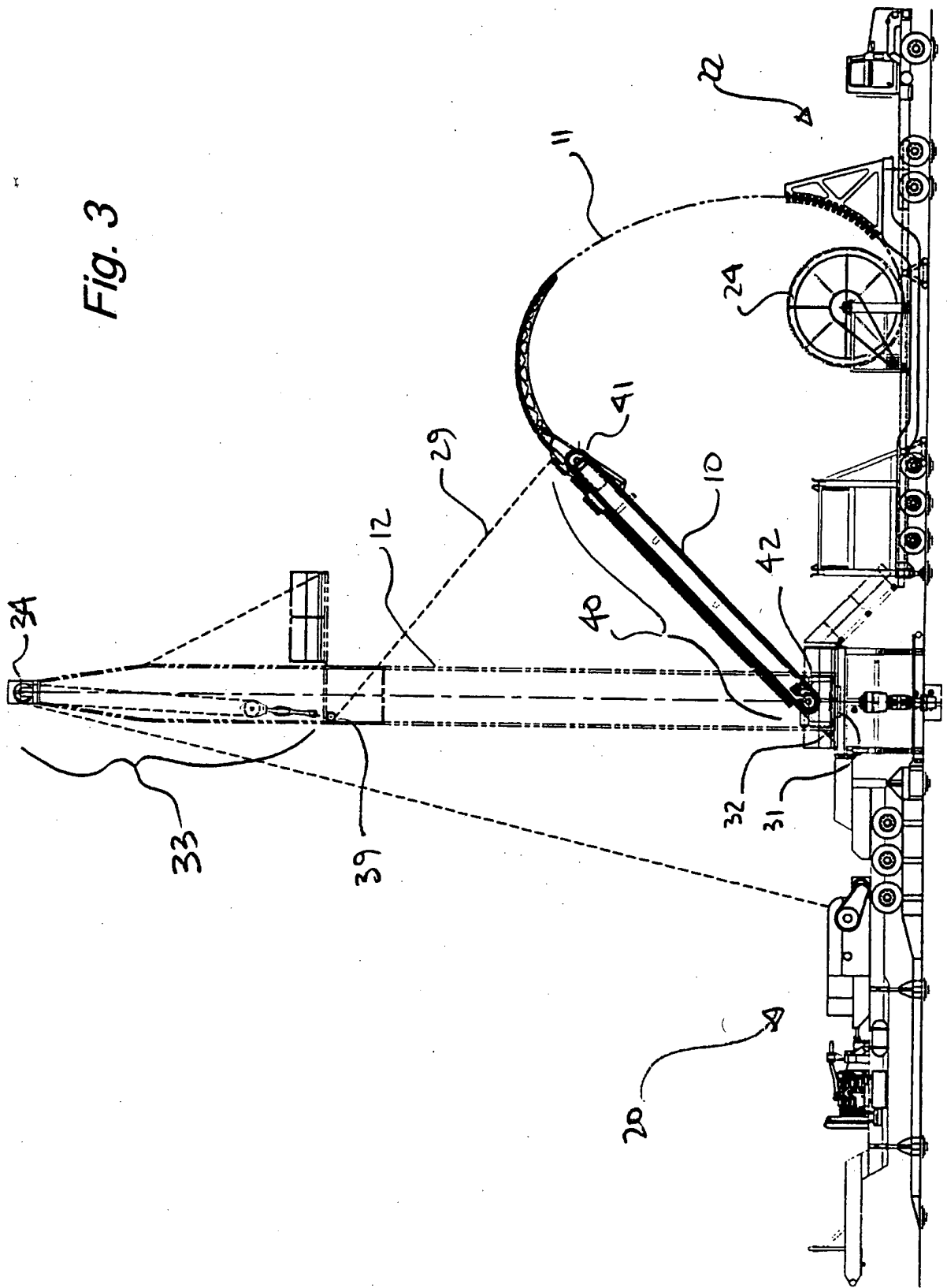
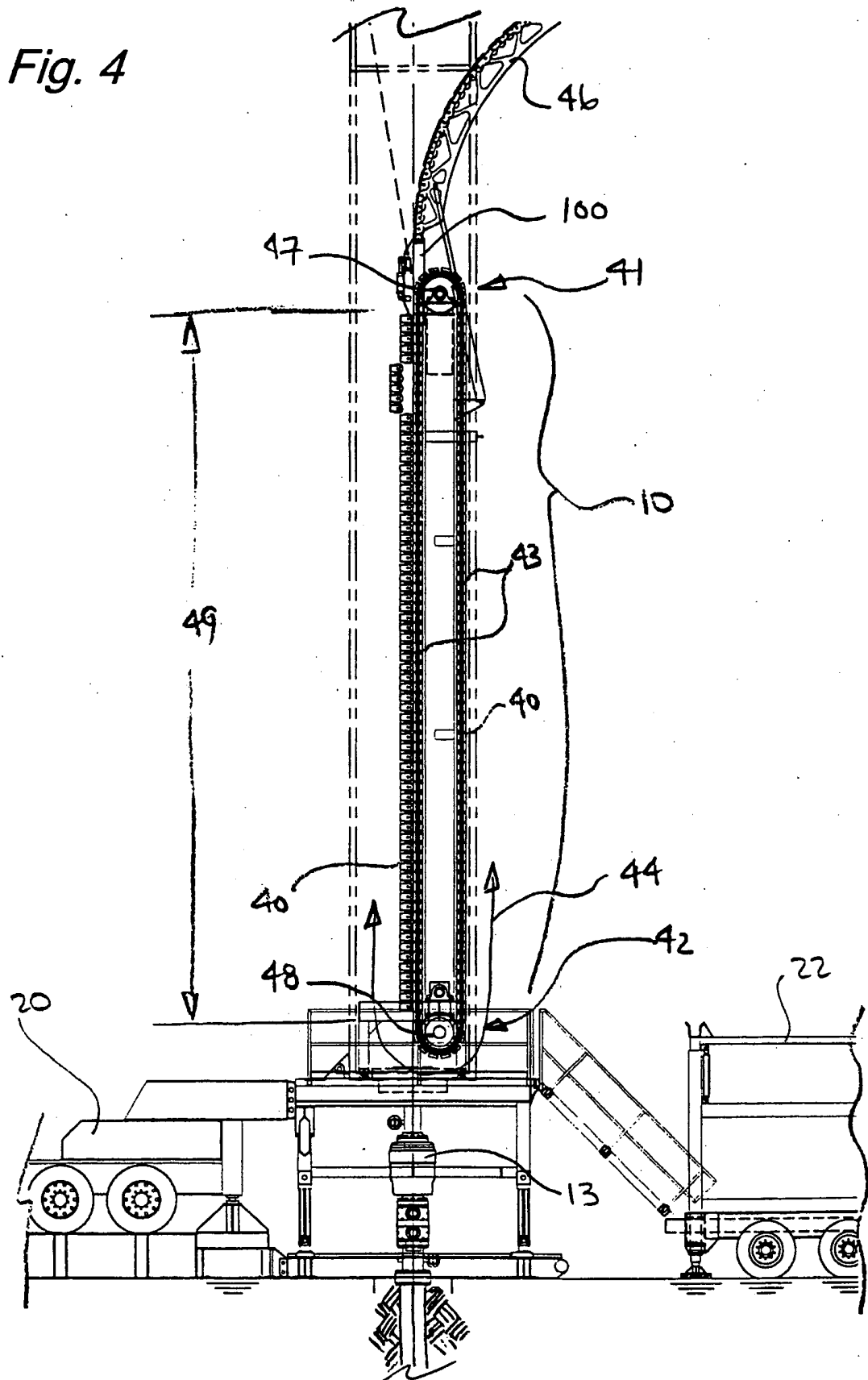
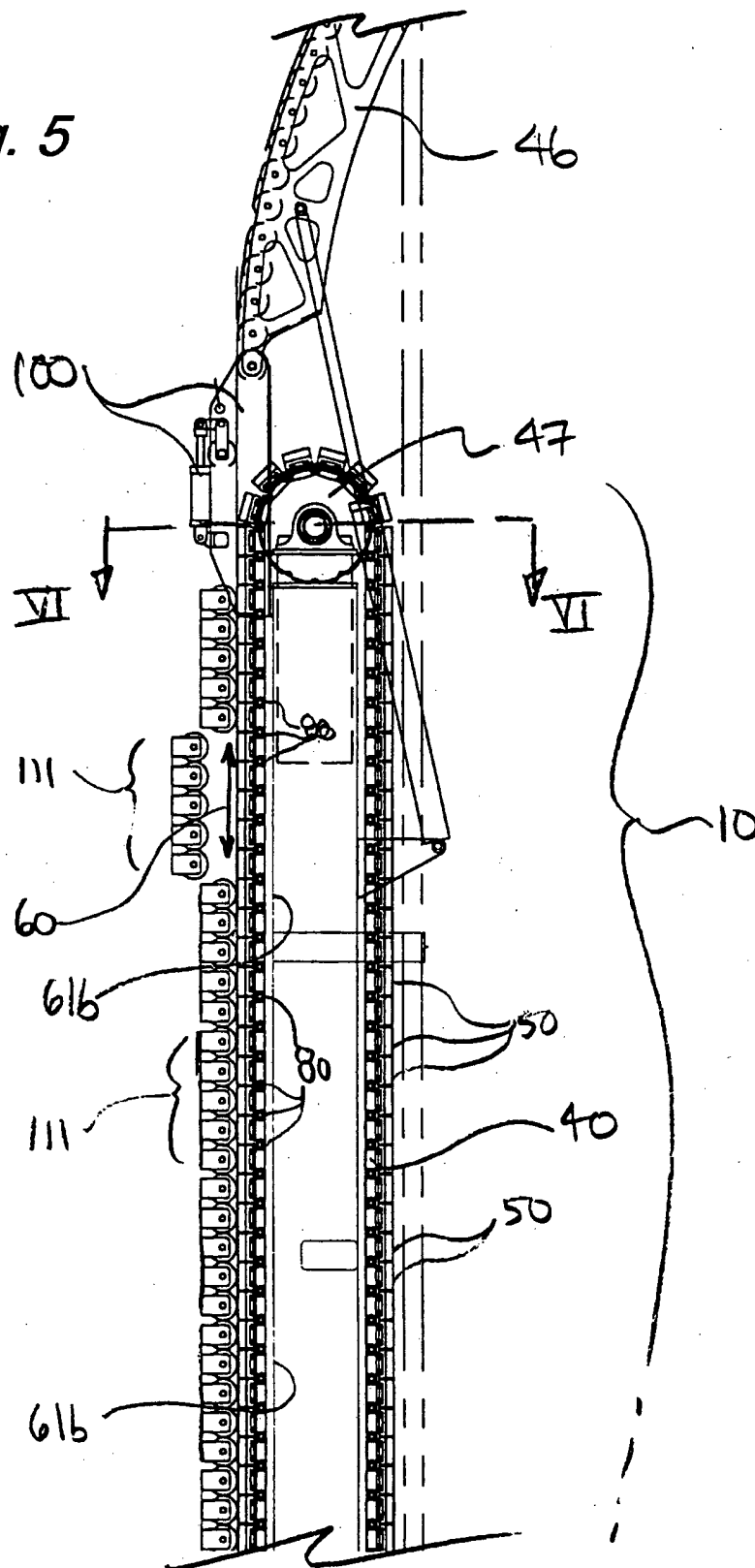


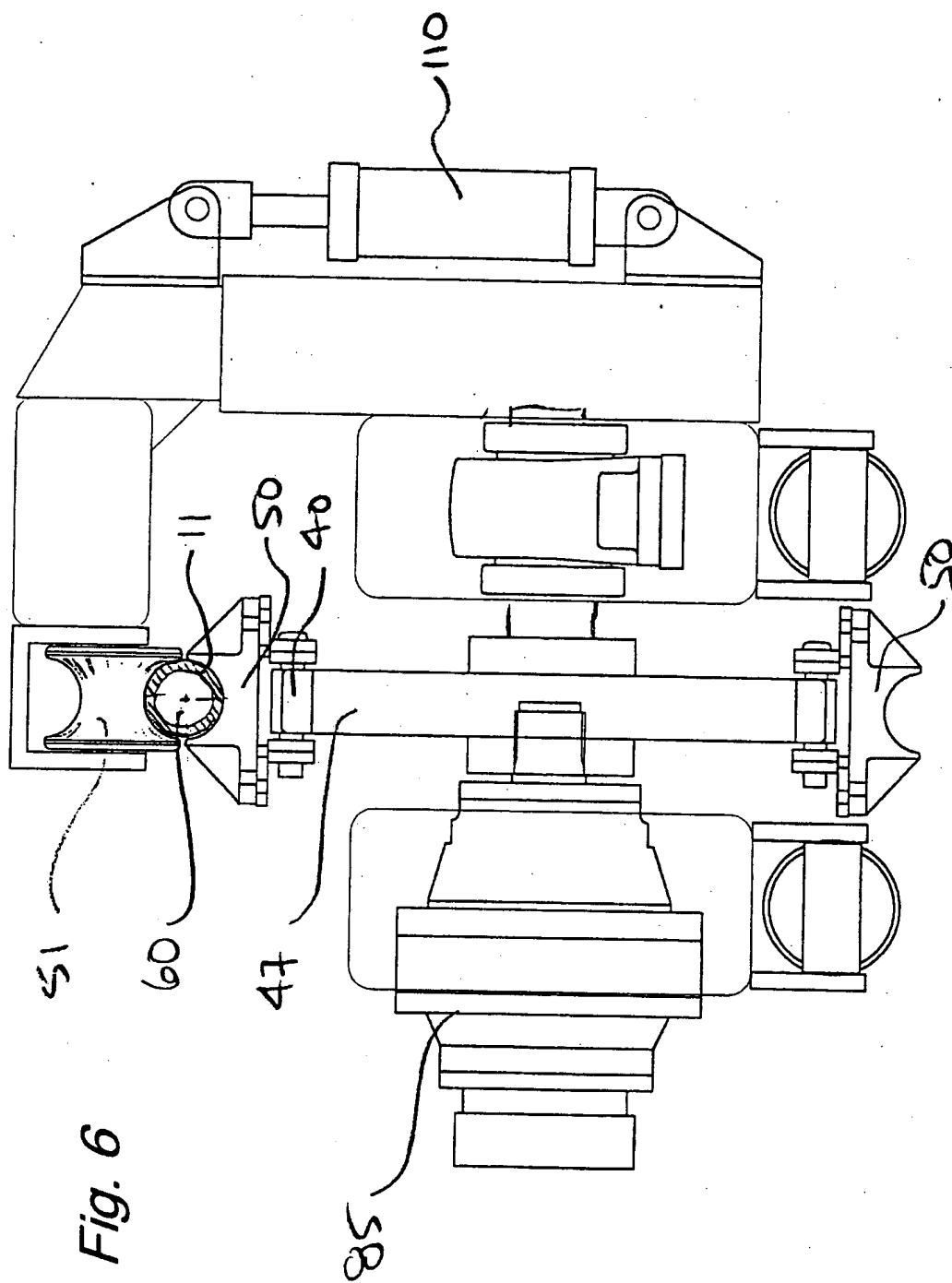


Fig. 4



**Fig. 5**





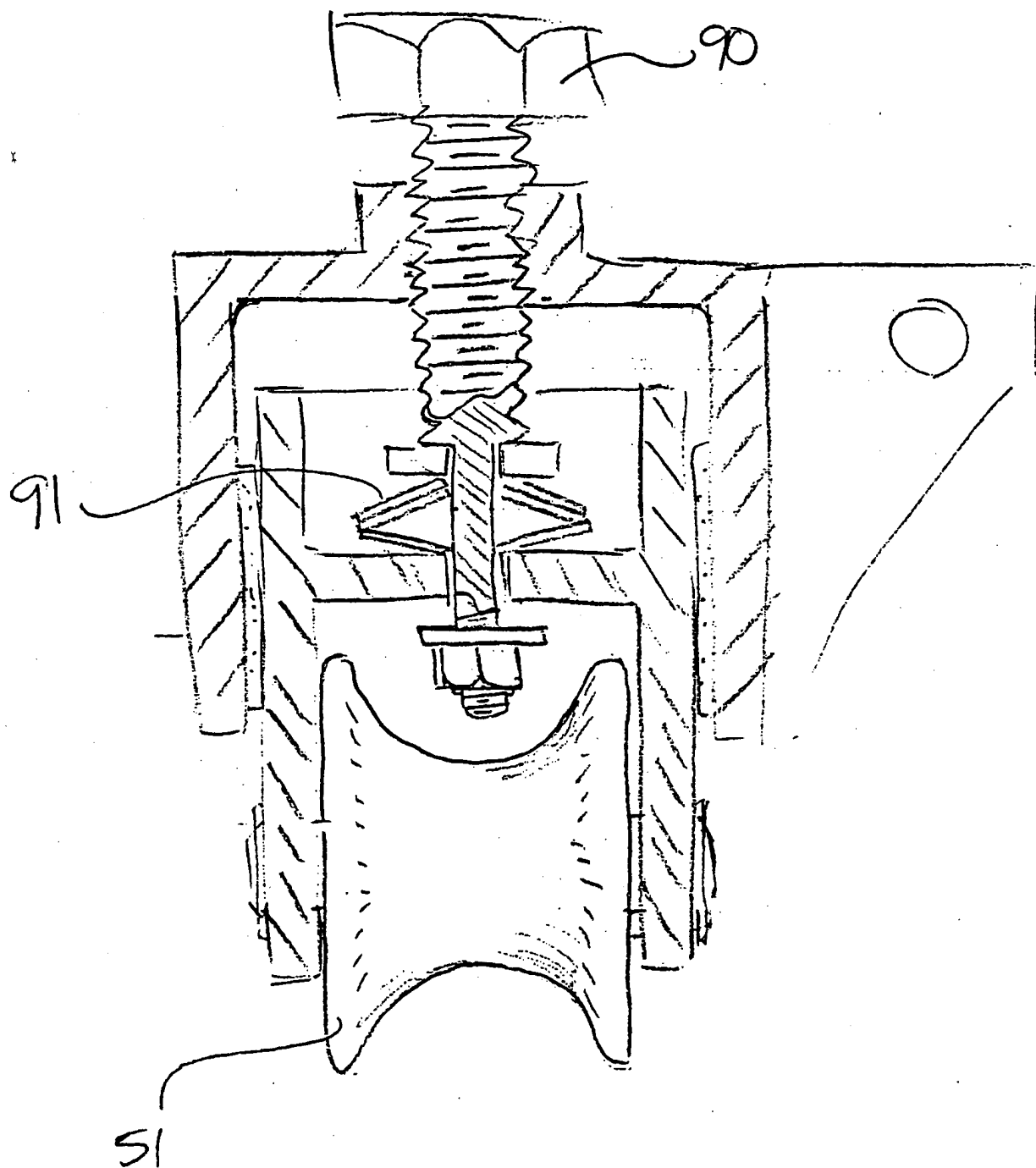
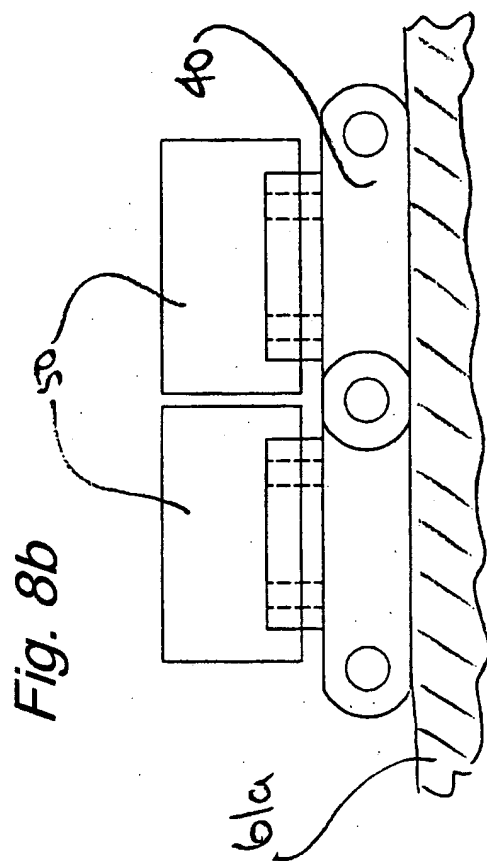
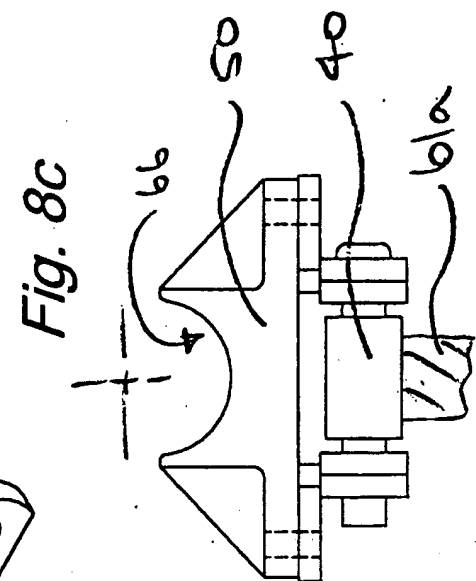
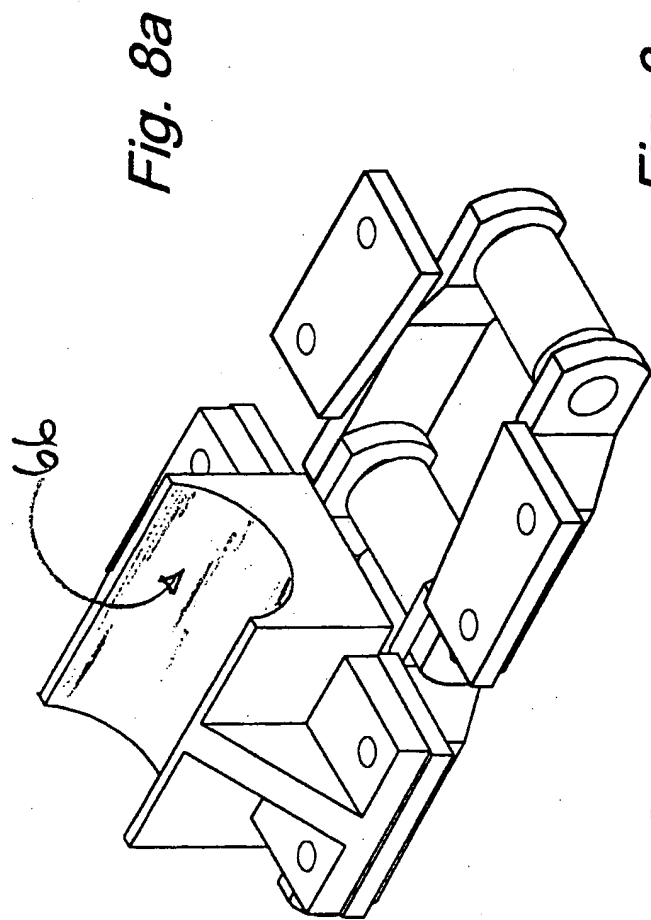


Fig. 7



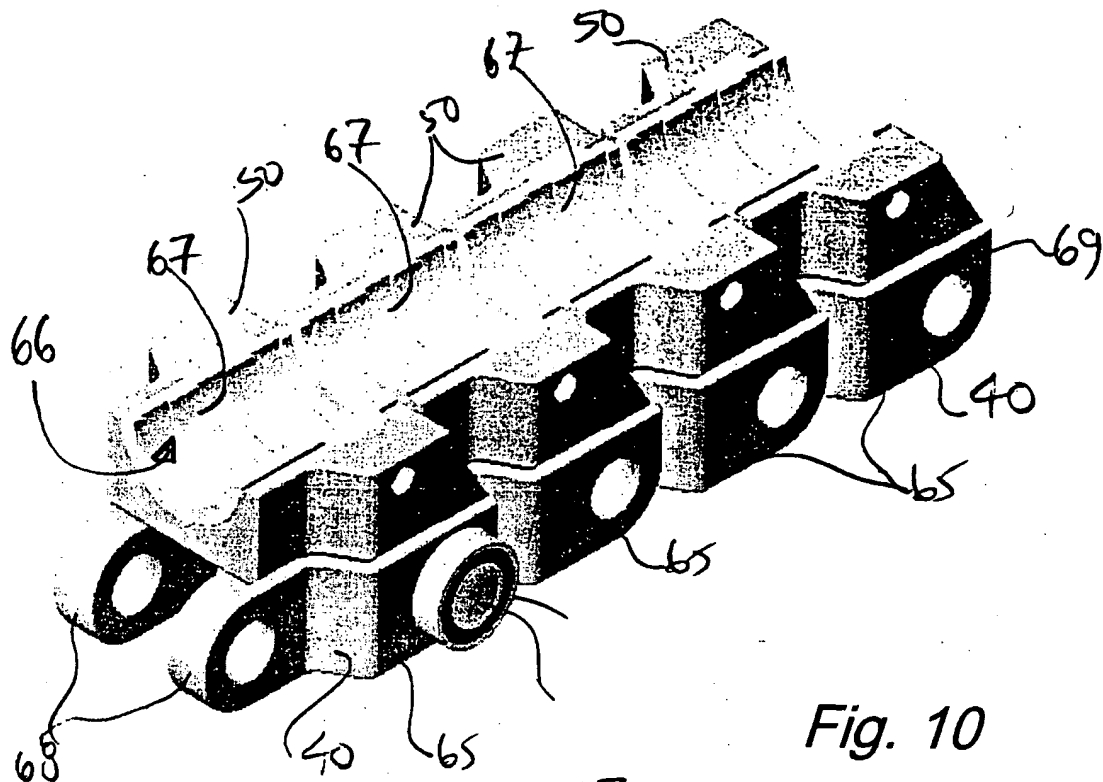


Fig. 10

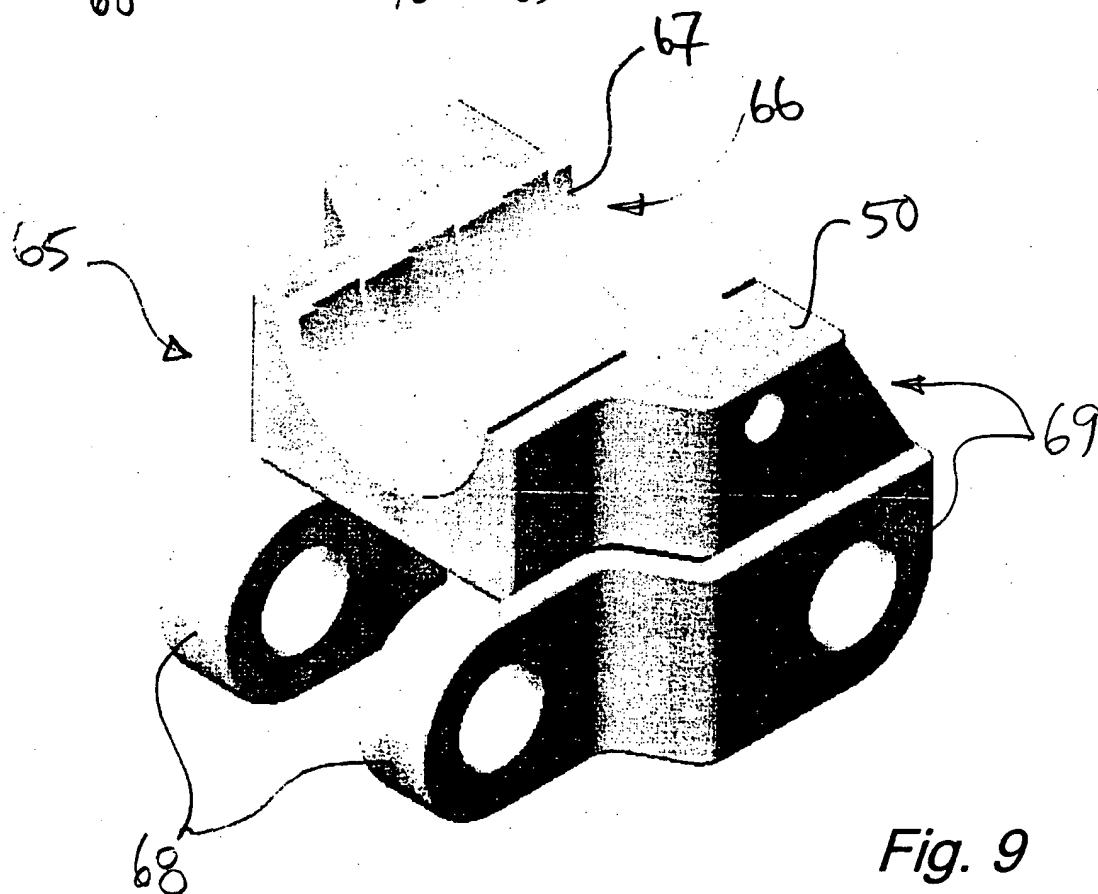
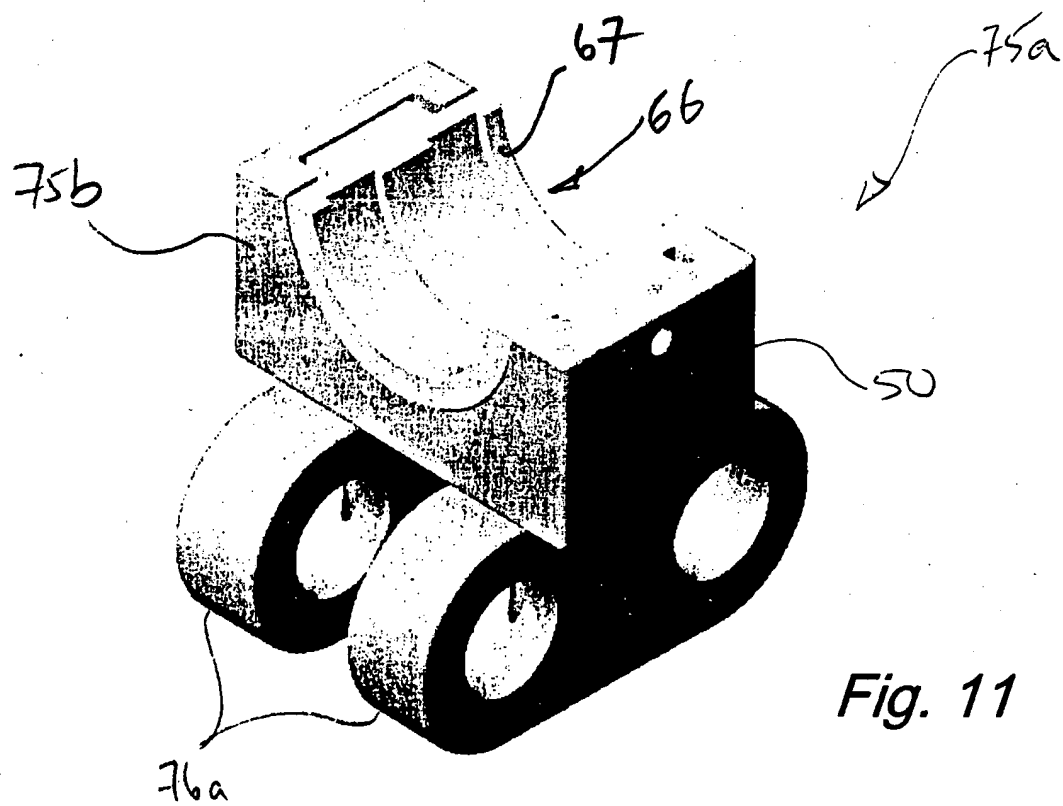
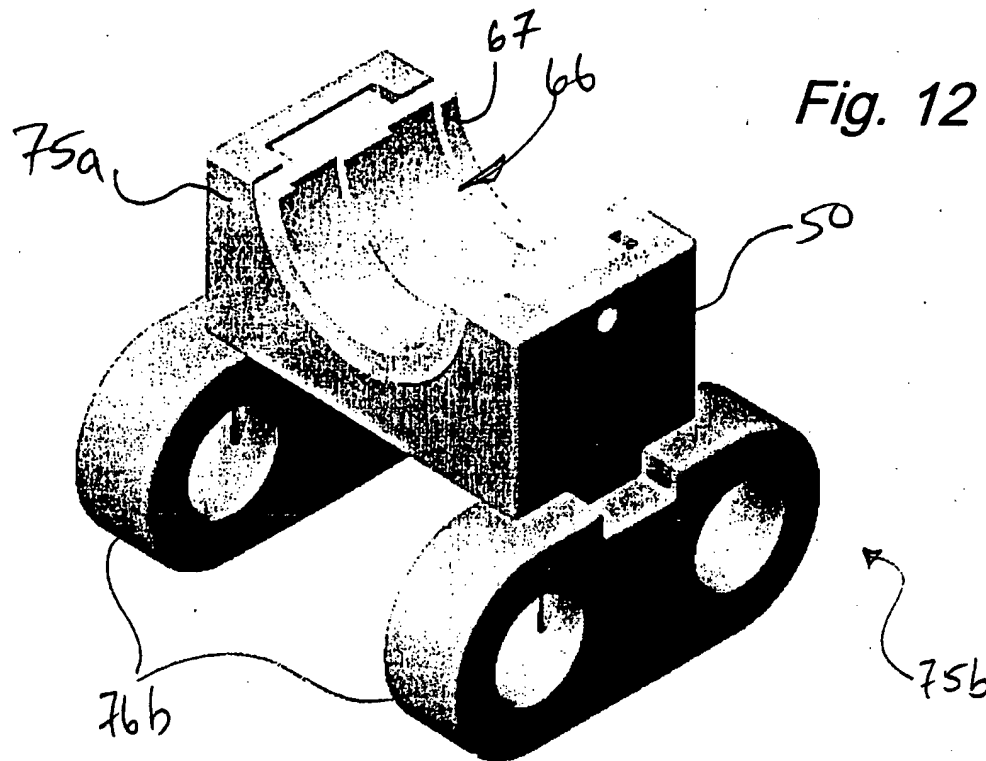
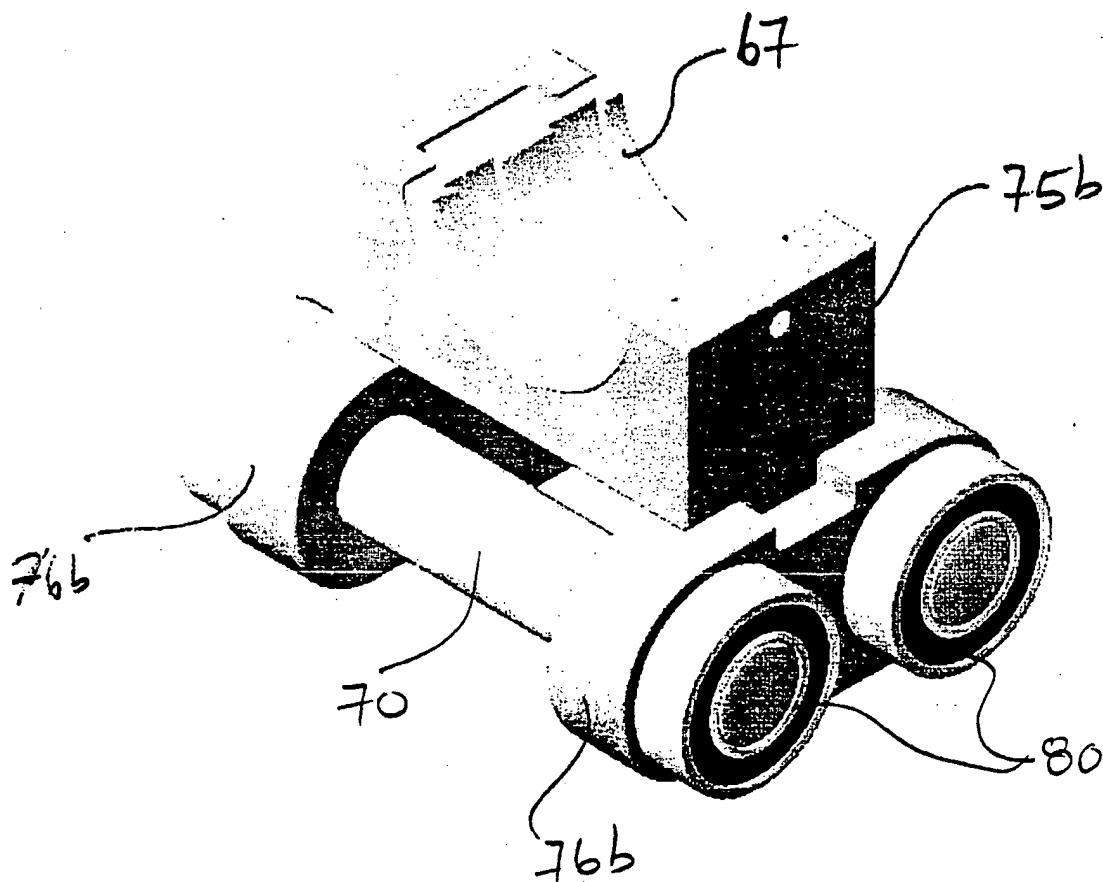


Fig. 9





*Fig. 13*



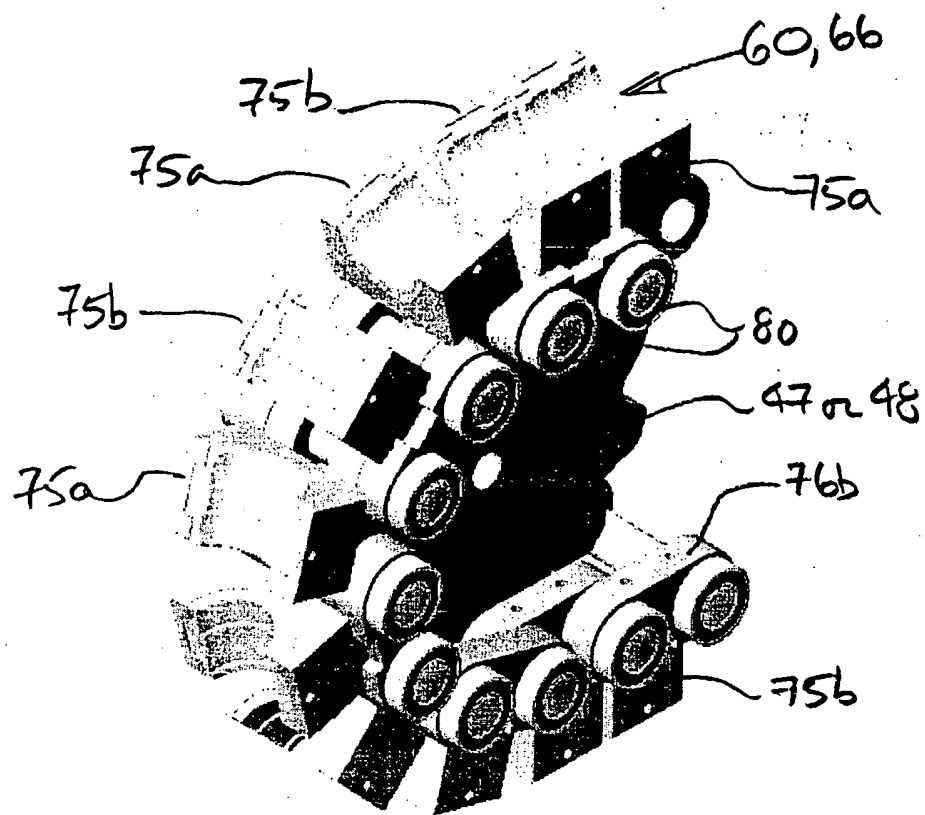


Fig. 14

